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SPITZER INFRARED SPECTROGRAPH (IRS)[1] OBSERVATIONS OF THE REDSHIFT 3.91 QUASAR APM 08279+5255[2]

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ABSTRACT

The Infrared Spectrograph (IRS) on board the *Spitzer Space Telescope* has been used to obtain low- and moderate-resolution spectra of the dust- and gas-rich quasar APM 08279+5255 ($z = 3.91$). Broad Paα and Paβ recombination lines of hydrogen were detected at wavelengths of 9.235 and 6.315 μm, respectively, as well as a strong, red continuum that is a smooth power law over the observed (rest-frame) wavelength range 5.3–35 μm (1.08–7.1 μm). The observed Paα/Paβ line flux ratio of 1.05 ± 0.2 is far from the case B value of $\sim$2 and simple models of high-density, high optical depth ionized-gas regions ($\sim$1.8). This deviation is opposite in sense to the expected effect of reddening. No evidence is found in the spectrum for either the 3.3 or the 6.2 μm emission features usually attributed to aromatic hydrocarbons in gas-rich galaxies in the local universe. This is consistent with the high-luminosity active galactic nucleus (AGN) nature of APM 08279+5255.

Subject headings: galaxies: high-redshift — quasars: emission lines — quasars: individual (APM 08279+5255) — techniques: spectroscopic

1. INTRODUCTION

The quasar APM 08279+5255 was originally discovered in a survey for high Galactic latitude carbon stars (Irwin et al. 1998). At a redshift $z = 3.91$ (Downes et al. 1999), its brightness makes APM 08279+5255 apparently the most luminous object known in the universe. As originally suggested by Irwin et al. and subsequently confirmed by Ibata et al. (1999) and Egami et al. (2000), APM 08279+5255 is strongly gravitationally lensed, with a magnification of $\sim$100. The lensing reduces its intrinsic bolometric luminosity to a more modest but still large $\sim 5 \times 10^{13}\ L_{\odot}$.

Although APM 08279+5255 does not have a strong infrared excess for quasars (see, e.g., Wilkes 2001), it is a bright source in the *IRAS* Point Source Catalog (Joint *IRAS* Science Working Group 1989, hereafter JISWG89; Irwin et al. 1998). It has been detected in the millimeter and submillimeter continuum (Lewis et al. 1998) and in multiple CO emission lines (e.g., Downes et al. 1999; Papadopoulos et al. 2001), demonstrating that the lensed quasar system is dust- and gas-rich. The mass of molecular gas is $(1\text{–}10) \times 10^9\ M_{\odot}$, depending on the lensing magnification (Downes et al. 1999; Lewis et al. 2002). The presence of large quantities of gas and dust in such a high-redshift system makes it a prime candidate in which to search for complex molecules at high redshift. The spectral energy distribution of APM 08279+5255 at far-infrared and submillimeter wavelengths is well fitted with a blackbody of temperature $\sim$220 K (Lewis et al. 1998) and has a continuum level well above 70 mJy for observed wavelengths, $\lambda > 12$ μm. The spectral energy distribution of APM 08279+5255 is normal for radio-quiet quasars. Its unusual brightness makes it ideal for study by the *Spitzer Space Telescope* as an example of a high-redshift quasar and makes it of great interest for probing the nature of quasars at very large look-back times.

APM 08279+5255 was therefore selected as an Early Release Observation target for the Infrared Spectrometer (IRS) on *Spitzer*. The following sections describe the observations and data reduction, the IRS data, and their implications.

2. OBSERVATIONS AND DATA REDUCTION

APM 08279+5255 was observed by the *Spitzer* IRS on 2003 October 26 and 2003 November 23. In order to ensure proper target placement on the IRS slits, the spectroscopic observations were preceded by target acquisition in the IRS peak-up imager (Houck et al. 2004, hereafter Paper I). Table 1 presents the log of the *Spitzer* observations. For the low-resolution spectra, observations were obtained at two positions along the IRS slit to enable sky subtraction. High-resolution spectra were obtained of both the target and a blank nearby patch of sky that was used for sky subtraction. Because of the substantially higher signal-to-noise ratios of the November 23 observations, where there was overlap between observations on the two dates, we include only those data from November 23 in the subsequent discussion.

The data were processed through the IRS data pipelines at the *Spitzer* Science Center (Paper I) to produce calibrated data

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